transmission format. Accordingly, AM digital broadcasting techniques are outside the scope of this proceeding".[33]

It would be highly improper if AM Stereo standard selection were to be held up pending development of DAB compatibility. Such a policy shift would be directly contrary to established FCC precedent. Color television was required to be compatible with the existing monochrome broadcast standards, FM stereo transmissions were required to be compatible with existing

Power side CSSB capability: Power Side stations, pilot tone present or not, are not stereo transmissions since they do not convey stereo (i.e. two channel program content) information.[34] Reception of the Power Side signal on an ISB system stereo receiver takes on unusual sound characteristics that cannot be described as quality stereo. The effect is not pleasant so it is a mystery to Motorola why the stereo pilot tone is actuated on Power Side stations.

CTI's concerns about compatibility with Power Side appear to be misdirected. First, the economic penalty of obsolete Power Side equipment is small when compared to the investment in C-QUAM equipment. Second, Motorola C-QUAM decoders ignore Power Side and are, therefore, compatible if CSSB is compatible. ISB receivers will decode Power Side as a single left or right (not both) channel accompanied by unusual high frequency sounds in the opposite channel. If anything, it would appear that ISB is incompatible with present CCSB equipment.

Occupied bandwidth / monaural compatibility issues: AM Stereo transmissions are required to be compatible with monaural broadcasts as demodulated by existing envelope detector receivers. In the Comments, ABC's Mr. Resnick notes that a linear quadrature system, like that which was originally proposed by the Harris Corporation, theoretically occupies no additional spectrum over a conventional monaural broadcast. However, detailed examination shows that such a system has two major disadvantages: 1) compatibility with existing receivers, and 2) linear amplification requirements cannot be fulfilled on many real world transmitters and result in a spectral occupancy that may far exceed that of C-QUAM.

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[34] In fact, there may be a question of the legality of Power Side transmissions. Terming such transmissions as stereo "seems" to skirt the issue, but international agreement with Mexico and Canada indicate that MW broadcasts consist of either A) a double sideband, full carrier monophonic transmission; or B) stereophonic (i.e., two channel stereo) transmissions of a type accepted format. Since the Power Side system alters the audio to send most of the signal in one sideband, there is a question of compliance with international agreements.

Harris acknowledged the CPM envelope compatibility requirement by introducing the VCPM system which dynamically controlled the L-R incompatibility content applied to the quadrature modulator during transmission. A varying pilot tone was transmitted which correspondingly altered its own frequency and theoretically allowed a receiver to demodulate and separate the stereo signal. The resulting received signal to noise plus interference ratio was subject to about 12 dB variation in the L-R channel. These signal to noise variations were undesirable and the pilot tone was later fixed at 55 Hz. In this latter linear system variation, L-R was still dynamically altered at the transmitter, resulting in undesirable variations in stereo separation at the receiver. However, even with the transmitter "compatibility controller", sporadic objectionable envelope distortions were experienced under program conditions. The distortion was particularly apparent when compared with a monaural or C-QUAM broadcast of the same program material.[35,36]

The transmission of linear quadrature signals also introduces modulation and spectrum compatibility problems. The easiest way to transmit QUAM is to generate it at a low level and amplify it using a linear amplifier. The cost of using such an amplifier is too expensive. Therefore, in the real world, the non-linear technique of envelope restoration is employed to generate the signal. Essentially, the linear signal is broken into its non-linear components of Envelope modulation and Phase modulation. Each of these signals is very non-linear. Each exhibits higher order sidebands which must precisely cancel in the combinatorial transmission process if restoration of the linear quadrature signal is to be completed. The envelope components, including all higher order terms, must not only pass through the modulator stage of the transmitter to the power amplifier, but must also be amplitude and phase coherent. One of the components is a

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[35] In 1983, Motorola supplied the Commission with example tape recorded passages of musical selections which were envelope demodulated using a Harris exciter as the signal source.

[36] Attempts to utilize linear QUAM have historically resulted in disappointment since one must compromise performance of stereo separation vs monaural compatibility distortion vs signal to voice characteristics.

DC term which is extremely difficult, if not impossible, to couple through in many transmitters. The poly-syllabic low frequency components present are also very strenuous to transmitter power supplies. In fact, some transmitters simply cannot handle the added strain and do automatically shut down unexpectedly in the presence of these lower frequency components.

Newer PDM transmitters also pose serious problems to envelope restoration. The series filters which remove the switching components and difference frequency sidebands centered at the switching frequency interfere with the need to pass higher order envelope terms without attenuation or phase shift. But if the non-linear envelope harmonics are not precisely matched to the non-linear phase modulated sidebands, large additive sideband spectra may be generated rather than the desired "cancellation" of spectra. Hence, linear QUAM occupied bandwidth may far exceed that of C-QUAM.[37]

Occupied bandwith: The spectra of a modulated compatible AM Stereo broadcast is complex. Program material is a distribution of modulating frequencies which tend to peak in amplitude in the several hundred Hertz range, and then to continuously roll off at frequencies above 1.5 kHz. This holds true even with the levels of pre-emphasis utilized today.[38] The net result is a reduced modulation index at higher frequencies which results in excellent spectral compatibility.[39] It

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[37] Motorola has, in the past, cited examples of this conditions occurring in stereo transmitters utilizing linear QUAM. See the Further Notice of Proposed Rulemaking, Docket 21313, Reply Comments, Replies to Harris Corporation, page H-80A.

[38] See American Institute of Physics Handbook, 1957, McGraw-Hill, Chapter 3, Page 133, (for speech); and National Radio Systems Committee, Interim Voluntary National Standard, 6.3.2, first issued January 10, 1987, (for music), (USASI voice weighting).

[39] Verifying spectra photographs have been submitted by Motorola to the NRSC Committee and to the NAB Engineering Handbook. In addition, each AM Stereo C-QUAM exciter which has been type accepted

should be noted that C-QUAM has also been tested and accepted internationally for occupied bandwidth criteria in Region 1 and 3 countries which rely on CCIR specifications.[40] In every case, the on-air spectra of C-QUAM has been shown to be virtually indistinguishable from that of monaural broadcasts.

The Hershberger comments contend that Motorola, in its application for type acceptance of C-QUAM, failed to perform all required occupied bandwidth tests required under Rule Section 73.44. The argument is factually incorrect and is based on erroneous interpretation of the pertinent rule. The rules limit the audio response of an AM transmitter to 10 kHz. Hershberger's bandwidth criticisms of C-QUAM are premised on single tone modulations at frequencies greater than 7.5 kHz. However, the Commission does not require tone testing at frequencies above 7.5 kHz because program material frequency response is distributed and gradually rolls off (even with pre-emphasis) at higher modulating frequencies. It does properly require relevant program material related tests. EBU follows a similar bandwidth measurement requirement using 30% CCIR weighted noise modulation of the transmitter.[41,42]

C-QUAM broadcast equipment licensees of Motorola have also all submitted, as part of the type acceptance data required by the Commission, spectra tests of sine wave tones up to 7.5 kHz and of program material under the conditions of L+R, L-R, Left channel only, Right channel only, and

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[40] Australia, Japan and other Region 1 & 3 countries where C-QUAM is in use base occupied bandwidth measurements on CCIR recommendations; Australian specifications reference #M84/1292, Australian Department of Communications, Section 5.4-2.

[41] Mr. Kahn provided information in the mid 1950's which also indicated the rolloff characteristics encountered in music and speech. His work was performed when he was promoting Compatible Single Sideband (CSSB) which also exhibits compatibility sidebands.

[42] Harris proposed that a weighted set of 5 tones (2 of which were below the cutoff frequency of the 200 MHz high pass filter required at that time for the Harris system) be used to measure the stereo signal characteristics since this more closely represented a stereo signal than did a single tone.

stereophonic programming using NRSC audio processing. The most recent of this data is that submitted by Nautel Corporation for type acceptance of its new line of stereo transmitters.

Field audits have repeatedly shown that the spectra of the C-QUAM system is well contained. The NAB Engineering Handbook also illustrates stored spectra of a number of Chicago C-QUAM systems on air.

The criticisms of the C-QUAM occupied bandwidth are factually incorrect. Furthermore, the recommended alternative system has a seriously flawed spectra characteristic.

Stereo distortion: Mr. Hershberger is encouraged to study the modulation specifications for the C-QUAM system, including the -75% single channel limit. Since C-QUAM is an envelope compatible system, it cannot send information at -100%. The transmitter simply has no output power at this modulation point. But L-R modulations are allowed up to this point provided that the level of modulation is controlled. This control is provided by a single channel limiter, which is part of the C-QUAM system technical requirements. By comparison, a linear system can theoretically provide continuous modulation simply because the envelope does not cutoff at minimums of L+R but changes 90° in phase. But these characteristics are also what cause the linear system to produce its incompatibility distortions to envelope detector monaural radios.[43]

Given the history and present status of C-QUAM , any distortion problems would have been unearthed repeatedly and would have doomed the system forever.[44]

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[43] In practice, AM transmitters cannot accommodate linear system modulations that require 180° carrier phase reversals. Hence, their levels of modulation must also be closely controlled.

[44] In his comments to the Commission, Mr. Hershberger cites computer synthesized simulations of the C-QUAM system. These simulations apparently prepared to depict a hypothetical worst case scenario, do not agree with laboratory measurements. Test conditions of 60% left channel and 40% right channel using the same tone

Standards for AM stereo receivers are inappropriate and beyond the scope of this proceeding. Some commenting parties suggest that this proceeding should also set receiver standards. To do so, however, would be beyond the scope of the NPRM which is limited to those broadcast standards which directly describe the AM Stereo signal and to changes required to the current rules. Current FCC rules are already in place which address the relevant receiver-based issues. These rules, reflecting comments previously submitted, provide substantially increased protection ratios and interference safeguards, including the NRSC-3 RF emissions mask, which has been widely published.

To state the obvious, there is simply no credibility to the assertion that the C-QUAM system has been a disaster wherever it has been used. C-QUAM is on over 1000 stations worldwide; there are 25 - 30 million C-QUAM receivers; six countries, including Japan, have adopted C-QUAM as a standard; six broadcast companies and 42 receiver manufacturers have licensed C-QUAM . Granted, growth could ideally have been faster, but it has never stopped and the recent Japan experience is a fine example of how well C-QUAM has been accepted when adopted as a standard.

The compatibility of C-QUAM broadcasts has already been extensively documented in tests held over a number of years and involving many countries. These tests demonstrate conclusively that the envelope of the radiated C-QUAM signal i (1+L+R), the requisite performance standard. Examination of published spectral photos of C-QUAM broadcasts shows that out of band radiation cannot contribute to increased distortion on monaural receivers under program conditions - even

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results in 100% L+R modulation and 20% L-R modulation and not the 10% L-R as reported by Hershberger. Motorola duplicated the Hershberger modulations using a laboratory generator with the following findings: Left channel distortion 1.27%, right channel distortion 1.7%, at 1000 Hz. Motorola then expanded on Mr. Hershberger's tests by modulating the left channel to 40%, 1000 Hz, and the right channel to 60%, 400 Mz. This condition exercises C-QUAM to 100% peak envelope and also 100% peak L-R modulation components. The measured distortions were then: Left channel 1.27%, right channel 1.62%. Motorola does not believe any other stereo system will perform any better than C-QUAM under these tone modulation conditions.

with extremely heavy pre-emphasis and processing. The most recent tests conducted in Japan included extensive compatibility measurements. The C-QUAM system was found to be fully compatible with existing receivers. Previous tests in other countries such as Australia and Canada, as well as on air operations in the United States also established complete compatibility. The evidence is overwhelming and there is none to the contrary.

C-QUAM does not, as suggested by some commentors, result in lost monaural station coverage. The envelope signal for C-QUAM , as for any compatible systems, is (1+L+R). Any loss of coverage experienced by stereo stations properly operating with any compatible stereo system is solely a function of audio processing. If incorrect discrete (left and right channel - FM style) processing is used, up to 6 dB can be lost under certain program conditions. However, modern AM Stereo matrix processors insure that no loudness is lost in modulation. [45] In fact, the C-QUAM system, as compared with the ISB system, is the easiest for audio processing to accommodate and still maintain full monophonic loudness compatibility.

Criticisms concerning the occupied bandwidth of the C-QUAM system are without merit. Published spectral photographs and type acceptance data of several C-QUAM manufacturers on file with the Commission verify compliance with all applicable rules. The NPRM indicated that any proposals to modify these rules would not be within the scope of this proceeding.

The C-QUAM system is robust. The AMAX committee has shown that under entertainment quality signal to noise conditions, C-QUAM is capable of FM-like performance. Under conditions

[45] A case could be argued that the Kahn ISB system loses loudness or coverage due to its SSB nature. The ISB system, which employs phase shifters, introduces large (6 dB) overshoot peaks into the envelope which must be re-clipped prior to transmission if loudness is to be maintained. But the process of clipping the signal after phase shifting upsets the left / right sideband structure adding distortion and additional processing artifacts. The C-QUAM system, due to DC coupling through the exciter modulator circuits without phase shift circuits, does not encounter these problems. Of course, on program material, the ISB effects are lessened because of fewer incidents of overshoot occurrence.

of poor signal to interference ratio (16 - 20 dB), algorithms designed into C-QUAM decoder IC's readily extend the coverage capabilities of the system.[46] The next generation of decoders and the present generation are functionally capable of taking advantage of any benefits of synchronous detection. This latter option is the subject of ongoing evaluation but, thus far, has not gained the acceptance of receiver manufacturers. The benefits of synchronous detection only occur under reception conditions that are so poor that the consumer switches stations. Hence, receiver manufacturers have not opted to incorporate this feature.

C-QUAM sensitivyt to interference: Mr. Hershberger states that the C-QUAM receivers revert to monaural reception and cause distortion under the influence of interference. The comment is based on outdated information and, in any event, is irrelevant. The family of C-QUAM IC's have for a number of years been designed so as to blend the interference levels drop below 20 - 26 dB, thus giving the receiver manufacturer the option of extending the listenable range if desired.[47] The action is very similar to what is done with FM stereo decoders.

The effects cited by Hershberger do occur with older C-QUAM decoders when the interference ratios are well below 26 dB. In fact, the ratio has been found to be much closer to 16 dB. But consumer electronics manufacturers and the results of a recent survey conducted for the NAB (the B. Angel study) indicate that consumers will not listen to interference levels below 26 dB for forgiving program material, and 40 dB for talk programming. At these levels, the concerns indicated by Hershberger are not relevant.

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[46] Older C-QUAM IC decoders did revert to mono under these extremely poor reception conditions. However, this did not occur except under conditions wherein the receiver manufacturer presumed the listener would have changed stations anyway. At any rate, this was not a system limitation, but was a decoder design characteristic.

[47] Several reports have been filed on the fine performance of receivers using these new IC's including an article found in Radio Broadcast Review, on page 24 of the 9-7-92 issue.

Technical criticism was also directed at the "platform motion" of C-QUAM whenever the co-channel desired to undesired ratio drops below approximately 20 dB. To repeat, these are interference levels below the point of consumer acceptance. C-QUAM acceptance in spite of over 15 years of platform motion criticism, both domestically and internationally, shows that this has been determined to be a non-issue.

Motorola knows of not one of the over 1000 domestic and foreign C-QUAM stations that has lost coverage due to conversion to C-QUAM. Furthermore, there is no valid technical reason to suspect any other result.

CERTIFICATE OF SERVICE

I, Alice M. de Séve, of Motorola Inc., do hereby certify that on this 20th day of April, 1993 a copy of the foregoing "Comments" was sent to each of the following by first-class mail, postage-prepaid except where service by hand is indicated(*):

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